RISK SYMPOSIUM/short

In an age when the land area of our planet has been explored, mapped, imaged, settled and in most cases exploited for whatever it has to offer…

…it is definitional that what remains to be explored are the most remote, inaccessible and inhospitable parts of our world.

Or not a part of our world at all.

The remaining frontiers here on our home world are mostly beneath the sea. And the good news is that what we have seen and explored of that dark realm is only a tiny percentage.

And of course the frontier of space is infinite, and we are barely on our first steps of that epic journey.

But the bad news is that all the easy stuff has been done.

Which means that we are now confronting very hostile and extreme conditions, and requiring more sophisticated machines and support systems in order to do our exploration.

And, correspondingly, we are facing more complex and subtle forms of risk than ever before.

I have lived with risk my entire professional career. As an action film director I have regularly asked people, with absolute seriousness…

… to set themselves on fire, to crash cars, to leap out of exploding buildings, to ride on top of skidding tractor trailer trucks, to fly helicopters under freeway overpasses with two feet of clearance… and even to ride a sinking ship down under the water.

In twenty years of directing stunts, action and pyrotechnic effects I have never had a serious injury on the set.

Before any major stunt, or gag as we call them, I would walk the set, looking at every piece of rigging, turning every possibility in my head.

By that moment, when all the lights and cameras were set up, it was the culmination of months of planning, engineering, testing and rigging… all done by the industry's leading experts.

Between them they had many decades of experience in doing stunts, explosions, car gags, fire… whatever it was we might be doing.

But still, after every one had signed off, I would walk the set, once again… looking at the rigging, asking questions. What if this happens. What if that happens. Even though we had been over it and over it.

I walked the set, looking for something…

I call it the X-factor. Some previously unseen detail, some combination of variables which could cause the stunt to go horribly wrong.

The personal touch is critical.

Systems, protocols, institutional checks and balances are important, and add great robustness to risky operations…

… but those very checks and balances often inhibit individuals from speaking up or taking action, because they make the assumption that someone else has approved it, or someone else will catch it, before it is too late.

When we made the movie Titanic, we began that production in a very unusual way. We actually dove to the wreck of the Titanic in 12,500 feet of water, and filmed it.

We set ourselves some ambitious goals. We would build a new camera system, which would allow 35mm movie filming outside the submersible at 5500 psi of ambient pressure, we would build new lighting equipment… and we would build our own remotely operated vehicle to launch from the Mir submersible to explore Titanic internally.

My experience in project managing the creation of new filming tools during the making of the movie "the Abyss" a few years earlier… prepared me for the difficulty of engineering the new equipment…

…but nothing prepared me for the chaos which was introduced when we took the whole circus to sea on a Russian research ship.

We weathered three hurricanes and multiple equipment failures, but we managed to prevail and get the precious images of wreck.

As a result I was bitten by the deep ocean exploration bug.

After the success of the movie, I found myself less interested in Hollywood film making, and more interested in the challenges of deep ocean photography and exploration.

Over the next few years we developed new imaging and robotic exploration technology. Then I raised money for some film projects which would help pay for all of it.

We returned to the Titanic wreck site in 2001 with a digital 3D camera system which allowed us to capture cool stereo images of the wreck. This was for a film called GHOSTS OF THE ABYSS which we were making for the Imax 3D theaters.

We had also created two small and very advanced ROV's which could fly untethered inside the wreck and explore it room by room, deck by deck.

They were launched from the submersibles, after we landed on the Titanic, and flown inside the wreck by myself and another pilot in tandem imaging operations.

With these "bots" we were able to capture some amazing images inside the wreck, in spaces which will be forever inaccessible to human eyes, other than through the proxy of our machine avatars. Their lights and video cameras reveal wonders of Titanic's lost elegance, hidden deep inside her rusting hulk.

It was the greatest adventure imaginable. If I wasn't hooked before, I was certainly hooked then.

Of course we had a lot of problems and equipment failures, and got hit by three hurricanes again… and then the September 11th attacks cut short our expedition.

It was bizarre and ironic to be literally down at the bottom of the ocean, at the site of the defining disaster of the early 20th century, while the defining disaster of the early 21st century was changing the world above without our knowledge.

Having made 24 dives to explore the wreck of Titanic, between the two expeditions, I am now continuously mindful of the lessons that disaster can teach us.

The lessons learned from the sinking of Titanic caused sweeping reform of the maritime safety code. But in the abstract, Titanic has many valuable lessons for us in the continuing exploration of the sea and space.

Titanic was sunk primarily by institutional momentum. Just as the inertia of the ship was too great for it to turn in time to avoid colliding with the iceberg, an inertia of methodology was equally responsible for that collision.

Sea captains at the time had a policy of maintaining speed until ice was spotted, then slowing when it became necessary.

This is simply how it was done. Titanic's captain was due to retire after this one last, prestigious voyage, the maiden voyage of the largest vessel ever created.

His lifetime of experience taught him that on a crystal clear night, in a flat calm ocean, he was safe maintaining full speed despite the marconigrams in his pocket warning of a huge ice field ahead.

With a warning to the officer of the watch to be extra vigilant, he went to bed as the ship barreled toward its fate.

Was this arrogance, or hubris? Not really. It was simply business as usual.

But these new ships didn't handle like the previous ones. They took longer to stop, or to turn.

So the old operating methods didn't really apply.
Conditions had changed, but the methods hadn't kept up.

It also required an unlikely combination of elements to create the disaster.

The flat calm of the ocean meant no swells were breaking against the iceberg, which reduced the ability of the lookouts to see it for a critical extra few seconds.

Their mistake had been to underestimate the perversity of the ocean, even when it seemed at its most benign.

And when the berg WAS spotted, the officer of the watch, First Officer Murdoch, was able to get the ship turned just enough to avoid a head on collision, but not enough to avoid a glancing impact.

As a result the berg compressed and deformed the side of the ship for a 300 foot length… enough to cause flooding in the first 5 watertight compartments, which was non-survivable.

In fact, this was precisely the only way to have sunk Titanic.

Murdoch did what he was trained to do, and he did it well and quickly.

But the helm orders he gave sealed the ship's fate. His training was not appropriate to that exact situation, and to the changed technology of the new larger ships.

In a crisis, we are utterly dependent on our training. We do not rise to the occassion, we sink to the level of our training.

It is critical that our training evolve as the technology changes.

There are a few interesting parallels between the sinking of Titanic and the loss of the Colombia space shuttle and her crew.

In both cases, there were unheeded warnings. And in both cases the warnings were dismissed not out of negligence, but for reasons which made sense based on experience and institutional memory.

In the case of Titanic, the crew were well aware, because of wireless messages, that ice lay ahead.

But because it was the way it was always done, they proceeded at full speed toward the ice field.

With Colombia, it was known from many past missions that foam could separate from the external tank and possibly strike the orbiter.

But that problem had been analyzed twenty years earlier and dismissed as a serious threat to mission safety.

When foam was observed during Colombia's launch detaching and possibly striking the shuttle, some engineers were concerned.

But because "this is the way we always do it", the warnings didn't propagate up the chain of command with enough force to change the outcome.

Cultural momentum and institutional memory had worked against Colombia, just as they had against Titanic.

The foam strikes were ruled out a generation earlier as insignificant. It was staring them in the face the entire time… foam strikes took place on many launches, but none had the final, fatal consequence.

New dangers are easier to spot than ones we have mistakenly learned to live with.

We must always question the assumptions.

Another parallel is that in both accidents, an unlikely series of events were required to cause catastrophe.

With Titanic, it was the unlikely event of the very first iceberg to be spotted, out of a large field of ice, being exactly in the path of the ship. And this occurring on a night without the slightest swell activity to assist in spotting the berg in time. And all of this happening to a new large class of ship whose crew were inexperienced in managing its mass in fast turns or sudden stops.

With Colombia it took the foam strike incident, compounded by the fact that this was one of the very few missions of recent years which did NOT go to the ISS.

Had it been a mission to the space station, it is likely the station crew would have seen the large hole in the carbon carbon leading edge of the left wing during proximity ops.

Then station could have provided safe haven for the Colombia crew while NASA scrambled to launch a second orbiter to get them home safely.

So the vanishingly small probability of a foam strike event damaging a flight critical component was coupled with the statistically low probability of a non ISS mission to create a disastrous outcome.

These low probability/ high consequence events are the hardest to plan for and prevent, especially when it requires a number of low probability events in combination in order to create a threatening scenario.

Titanic teaches us to be constantly vigilant, to assume nothing about our methodology… to constantly ask the question what are we doing wrong RIGHT NOW?

I have lived with the lessons of Titanic, and they have informed my judgment on subsequent expedition projects.

After our second expedition to Titanic, we looked for other projects with new challenges.

The following spring we imaged the wreck of the Bismarck 16,000 feet down in the North Atlantic.

Again this was stereo imaging of the exterior of the wreck, and 2D imaging with our ROV's… our bots… inside the wreck. This was done for a Discovery channel program we called Expedition Bismarck (available on DVD).

We followed that up with stereo imaging at 5 hydrothermal vent sites along the Mid Atlantic Ridge. After Bismarck we added a zoom lens and macro diopter to our stereo imaging system, and were able to capture some amazing images of the life which abounds at these deep ocean vent sites.

Excited by the imaging results, we decided to make a second Imax 3D film, about the life around hydrothermal vents.

I formed a partnership to buy and operate the two Deep Rover submersibles, which have a depth rating of 1000 meters. Those are wonderful subs designed by Graham Hawkes and Sylvia Earle.

Previously we had been working with the Russian Academy of Sciences, and their two Mir submersibles.

Though I had a good understanding of the working systems of those subs, resulting from the integration of our own equipment, I was about to get a rude awakening about just how difficult it is to operate a manned submersible system, especially starting one from scratch.

We began by assembling a new team to operate and maintain the Rovers. They were gathered from well established submersible operations around the US and Canada.

The first task was to tear the subs down to their frames and rebuild them for ABS certification, all the while making the modifications necessary to support our 3D camera, pan/tilt and lighting systems.

This was done at a workshop at my ranch in Santa Barbara. It proved to be a daunting task to get the subs reassembled and recertified in time for our filming operations.

But this was nothing compared to doing the mobilization of the subs on a new ship, which including developing the launch and recovery methodology from page one.

We went to sea with our new subs and met the Russian ship out at the Mid Atlantic Ridge.

There we performed some joint diving operations with the Mirs, including one dive which was a rendezvous of all four submersibles at the Lost City hydrothermal site, at a depth of 870 meters.

This operation was very complex logistically, and involved the creation of new operational protocols for the launch and recovery of four subs in the same theater at the same time.

Tracking, communications, and surface ship operations were all made more complicated by the number of submersibles in the water.

It is a tribute to the Russians, and their can-do spirit, that we were able to do this operation successfully.

What guided me through all of the trials and tribulations of the teething pains of a new submersible operation while making a logistically complex film… was my past filming experience and my healthy paranoia about the X-factor.

I found that the principles of risk management and safety assurance which I had learned as a film director were transferable to these new situations.

Of course there is an extensive body of established procedure for submersible operations, and we studied that rigorously and selected our team members on the basis of their experience with manned sub ops…

… but it seemed like almost everything we were doing was unprecedented, and it was often difficult to find existing guidelines.

Often we were making up our own protocols… whether it was for safe procedures to launch multiple subs…

… or to descend them together only a couple of meters apart for imaging purposes…

… or for our acoustic comms during the dive, which were in two different languages, or for our bottom proximity operations, where we had four subs and an rov all operating within a few feet of each other.

We were able to build on our experience from past dives, and we were able to anticipate and talk through in advance most of the contingencies which might arise on the dive.

Because of the complexity of our diving operations, we always preceded each dive with a joint dive ops meeting.

Models of the submersibles would be used to discuss the types of maneuvers we would try to do. Everything was talked out in detail. Where possible, we used bathymetry data and site maps to plan the operation.

This briefing was synthesized into a DIVE PLAN document, and issued to each of the four observers and two pilots of the MIR crews, and the two observers and two pilots of the Deep Rover crews.

Each crew got a dive plan which was individually tailored to their vehicle in terms of timeline and activities.

Individual objectives for each crew were noted in the plan's timeline, as well joint operations. Science sampling activities were clearly spelled out.

This typically involved a separate pre-dive meeting of the science group, who brought their requests and equipment requirements to the dive group 24 hours in advance of the dive.

Contingency plans and alternate activities for each submersible crew were noted in their individual dive plans.

This rigorous planning did not prevent problems on the dives, but it made the problems manageable, and helped assure the successful outcome of the expedition.

It is absolutely critical to create a mentality and a culture of safety within any organization which is doing exploration.

An example of an organization that I think deals exceptionally well with the management of risk is NASA.

NASA is very very good at what they do.

And when faced with a crisis of the magnitude of the Colombia disaster, they mobilize in way which is truly inspiring… not just to pick up the pieces and pore over the evidence to find the cause, but search their souls to figure out how to do it better…

… to prevent the problem from recurring not just from an engineering perspective but through change in their institutional culture.

And I can say with utter confidence that a foam strike to the orbiter will never again be responsible for the loss of a spacecraft and crew.

But something else will be.

I pray it is not soon, but I believe it is inevitable… ten, twenty years down the line… something completely different and equally improbably and unexpected will happen, despite the best and most diligent efforts of what may be the smartest single group of people in the world.

Because failure is a part of exploration. It is absolutely woven into the fabric of the act of exploration.

It is definitional that exploration means you are doing something that has never been done before. It is absurd to assume that activities without precedent can be done in complete safety.

If only the remote and hostile environments are yet to be explored, then we are inherently pushing the limits of human endurance and technological adaptation every time we advance the boundary of the known.

This is the most noble and challenging activity in which we can engage as a nation and as a species, but it is an activity which can and most certainly will exact a terrible price from time to time.

Of course it is absolutely important to use all of our accumulated knowledge and experience to make the endevour of exploration as safe as possible.

But safety is not THE MOST IMPORTANT THING.

This may sound like heresy, but it is a truth which must be embraced.

The most important thing is to ACTUALLY GO.

Because if safety were THE most important criterium, we would not go to Mars for 10,000 years. Because only then could we assure absolute, one hundred percent success.

Historically the success of cultures and nations has been a result of their ability to balance risk and reward… or put another way… caution and boldness.

The explorers, the sea faring nations of Europe, grew mighty from the wealth returned from the discovery and settlement of the New World.

Those societies who stayed home languished, those who embraced the unknown prospered.

It is said by some that we must solve our problems here on Earth before we explore space.

While this is an admirable humanitarian instinct, it is a fallacy. By that reasoning, Lewis and Clark would have been kept home until the problems of the East coast were solved, and a vast rich frontier would have been ignored.

Seen broadly, we are a species which owes its current success to exploration.

Exploration yields situational awareness which creates survival options.

I have a one year old son. He is a natural explorer. He is a fearless climber, a bold toddler going where no toddler has gone before.

He learns from his falls, but it doesn't stop him. This is the true soul of the human animal.

We understand inherently, in our cells, that we need to push outward.

But the problem with exploration is not the individual's perception of risk.

It is the institutional, national and political perception of risk.

Astronauts are smart people. Most of them these days are Phds in one thing or another… engineering, physics, medicine.

They know that riding the pointy end of a metal object screaming through the atmosphere at twenty times the speed of rifle bullet propelled by one long sustained explosion is not the same as sitting at home in your barcalounger.

They understand the dangers. They get it. They have assessed the risk…

…but their personal dream, their vision, not just for themselves but for the entire human race, dwarfs that risk.

They know the importance of what they are doing.

Because in their souls they are explorers.

It is not the astronauts who will hold up the progress of exploration.

It is the government which funds them, and the people which empower that government to act, which will set the limitations.

When Shackleton recruited his crew to trek across the Antarctic continent, he dangled the risk of death as an incentive.

Because in that simpler time only by cheating death in the harsh conditions of an alien land could the explorer assure himself a place in the history books.

The dangers posed by the unknown where part of the appeal.

But the frontiers which remain to be conquered can't be explored by a man on foot, with a few good dogs.

They require complex systems of machines and people…

These machine systems, and the army of men and women who staff them, can only be fielded by institutions… many of them government funded.

Institutions cannot enter into the task of exploration with that same virile gusto as Shackleton and his men.

Nor should they.

The power of an institution, whether it be NASA, NSF, NOAA, Woods Hole, MBARI, the Russian Academy of Sciences etc. lies in its ability to gather vast institutional experience… to build on the work of the past, to marshal teams of engineers to solve problems… to make the technology safer and more reliable over time….

Institutions have the ability to analyse failures, to document lessons learned, to establish operational protocols to prevent such failures in the future.

But where it comes unhinged is when the institution loses its ability to dynamically balance risk against return.

Institutions gravitate inexorably toward a value system in which ANY risk becomes unacceptable.

At which point exploration ceases.

We are lucky right now to be on a cusp of history, wherein a presidential mandate has put NASA back on track with a renewed vision for exploration.

As a member of the NASA advisory council I have watched over the last eight months as NASA has risen to the challenge of being radically retasked and re-organized, with vigor and a renewed sense of purpose.

NASA has reorganized around the guiding principle of exploration beyond Earth orbit… both robotic and human missions working in concert to explore our solar system and expand our human presence in the cosmos.

It is a wise plan, which doesn't require more money than is currently allocated to space programs, but repurposes that money in a way which will lead step by step to a return to the moon, and human missions to Mars and beyond.

It is doable, achievable, affordable.

But there is one real challenge. We must overcome the fear of failure which may inhibit future leaders from allowing these missions to proceed.

The Challenger accident was deeply traumatic to the national psyche. We were simply not SUPPOSED to fail in space. It did not track with our image of ourselves as winners, as achievers.

But we were assured that Challenger was a mistake which would not be repeated. That those guys were all fired, that the problem was fixed.

The loss of Colombia forced us to realize the truth.

Despite our best efforts, and billions of dollars spent paying some very smart and dedicated people to operate these missions… there will be losses.

I was heartsick after seeing the break up of Colombia. I wept for the crew, and for their families, and for the people of the greater NASA family.

I was also deeply afraid that the American people d would step back once and for all from the challenge of space.

But that's not what happened. Somehow, in the alchemy of the grieving process, Colombia became a catalyst for change.

Exploration has been resoundingly embraced…
… real exploration outside Earth's orbit… actually going out there for the first time in three decades.

So now we are on track again.

The challenge, however, will be this.

The only way to fail in landing humans on Mars, is to actually go.

If we study the problem, build tools and systems, and so on, for the next fifty years, we can jolly ourselves along that we are really honest to God going to do it someday… we are still those clever Americans who put a man on the moon back… when was that again?

We don't put our self image at risk.

But the second the button gets pushed, and we are really going, we enter a much higher realm of risk.

Failure is not an option was a good credo for getting the Apollo 13 astronauts back home safely, but as a driving principle it just doesn't work.

Failure must always be an option. Or we stop being an exploring species.

When I started our most recent expedition project, I called a summit meeting of my department heads, the people who would be responsible for building the new lighting, camera and robotic equipment we would need to create.

At the start of the meeting I wrote three slogans on a white board. These slogans were meant to challenge them to think about every activity in their work day, and every task which lay ahead of them, in a manner which would assure the success of the mission.

The slogans were these:

Luck is not a factor.

Hope is not a strategy.

Fear is not an option.

The first two, luck is not a factor and hope is not a strategy… were meant to convey my philosophy that to succeed in any complex task, it is essential to leave nothing to chance.

You need to make your own luck, by rigorous application of a robust process.

Good engineering, good operational planning, good communication, all the factors which lead to a successful operation… all of these principles must be applied every waking moment of the day.

Build in good safety margins, into engineering designs, into schedules, into every thought you have.

Test everything, in a disciplined fashioned. Don't guess, know the answer.

Anticipate every negative condition which might prevail, and assume it will happen.

Consider the ramifications of multiple failures happening simultaneously.

Have an A plan, a B plan, a C plan… and assume you will be on the C plan before your second cup of coffee on the first morning.

Because that's how it goes when you are at sea.

I wanted to scare them. I wanted them to respect their adversary… not just the ocean, with its unpredictable moods and harsh judgments… but the real adversary.

Entropy.

That tendency of the universe to go inevitably from organization toward chaos.

Be anti-entropic every second of the day.

The third slogan, fear is not an option… was meant to inspire the boldness which sees you through.

It was the yin to the yang of healthy paranoia which the first two slogans represented.

Because without a kind of faith… not in luck, not in passive hope… but in yourself and your team, and in the greater meaning of what you are setting out to do, you won't find the strength to go through with it.

So my message is that in whichever realm, be it space or deep ocean exploration, we need to balance that yin and yang of caution and boldness, risk aversion and risk taking, fear and fearlessness.

No great accomplishment takes place, whether it be a movie or a deep ocean expedition or a space mission, without a dynamic equipoise between the two.

Luck is not a factor.
Hope is not a strategy.
Fear is not an option.
